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Rapid assessment of fish communities on submerged oil and gas platform reefs using remotely operated vehicles

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ABSTRACT

Remotely operated vehicles (ROVs) provide a non-extractive approach to characterizing fish communities in complex habitats. Despite the demonstrated effectiveness of ROVs in studying reef fishes over natural hard-bottom and small artificial reefs, there has been little application of this technology to larger artificial structures (10s of m tall and wide). We explored the utility of ROVs in rapidly characterizing an assemblage of fishes associated with an artificial reef complex in the western Gulf of Mexico (26.9–28.2° N; 95.5–97.0° W) dominated by partially removed and toppled oil and gas platforms. This study reports on an efficient method to sample these structures, where we integrated depth-interval transect (DIT) and continuous roving transect (CRT) protocols to document fish distribution and community structure on 14 artificial reef sites. Consistent with previous hydroacoustic studies, south Texas artificial reefs exhibited a vertically heterogeneous distribution of fishes that varied with structure orientation. These reefs were dominated by economically important lutjanids and carangids, both of which presented sampling challenges due to their patchy distribution around these vast structures. The non-uniform distribution and mobility of these dominant taxa highlight the utility of adopting roving approaches to assess fish communities on these complex structures. We conclude our study with a discussion of important logistical challenges associated with micro-ROV surveys in deepwater habitats, and potential complementary approaches to assist documentation of demersal fishes inhabiting a persistently turbid bottom layer.

1. Introduction

Numerous studies have documented the dependence of fishes on complex nearshore and coastal habitats such as seagrass beds, oyster reefs, saltmarsh, mussel beds, and rocky shorelines (reviewed in Beck et al., 2001; Seitz et al., 2013). Unfortunately, fewer data exist for offshore benthic marine habitats where the study of fish communities is limited by a suite of logistical constraints. In general, these offshore habitats range widely in size (m^2–100s of km^2), and are often located at depths beyond most recreational and scientific diving limits (30 m). As a result, researchers often rely on other traditional fisheries sampling gears (e.g., hook-and-line, traps) over visual assessments to characterize these offshore communities, though such gear may be biased to certain trophic guilds and sizes (Bacheler et al., 2013; Gregalis et al., 2012; Patterson et al., 2012). In addition, the characteristic rugosity and sensitivity of high relief benthic environments pose new challenges to the use of these sampling methods in most areas.

Video-based approaches provide an opportunity to broadly sample a variety of species and size ranges of fish and increase visual survey times at depth. Accordingly, these approaches have been of prime utility to document diversity and abundance of fishes inhabiting offshore marine ecosystems. Video-based surveys have historically included drop cameras, carousels, manned diver cameras, and remotely operated vehicles (ROVs) (Bryan et al., 2013; Cappo et al., 2006; Murphy and Jenkins, 2010; Pacunski et al., 2008; Somerton and Gledhill, 2004). Due to reductions in their size and cost and the ability to maneuver around isolated structures, ROVs have become increasingly used by fisheries researchers over the past few decades. To date, the majority of ROV use in fisheries research has focused on abundance and diversity surveys of benthic species associated with natural habitat. There has been limited assessment of artificial structures, and especially reefs with large vertical relief (Table 1), where depth and sheer size of the structure

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Table 1
Summary table of previous ROV studies and the habitats and survey types used to assess fish assemblages.

Device	Habitat	Habitat type	Survey type	Reference
Hydrobot	Natural	Lake bottom	Horizontal transect	Davis et al. (1997)
MiniRover MK2/Phantom II	Natural	Natural substrate	Horizontal transect	Norcross and Mueter (1999)
Phantom 300/XTL	Natural	SE Alaska bays, coves, inlets	Horizontal transect	Johnson et al. (2003)
Seaeye Falcon	Natural	High relief rocky habitat	Horizontal transect	Martin et al. (2006)
Phantom S4	Natural	High relief pinacles and ridges	Horizontal transect	Koenig et al. (2005)
Commando II	Natural	Coral reefs	Horizontal transect	Lam et al. (2006)
Phatom HD2/DS4	Natural	Natural habitat	Horizontal transect	Butler et al. (2006)
Phantom S-2	Natural	Rocky reef habitat	Horizontal transect	Whitfield et al. (2007)
Phantom S-2	Natural	Rocky reef habitat	Horizontal transect	Whitfield et al. (2007)
VideoRay Pro II	Natural	Sand, shell-rubble, natural reef	Horizontal transect	Wells et al. (2008)
Phantom DS4	Natural	Shallow natural bank	Horizontal transect	Jones et al. (2012)
DOE HD 2	Natural	Deep water, hard bottom	Horizontal transect	Karpov et al. (2012)
Phantom S-2	Natural/artificial	Natural hardbottoms, shipwreck	Horizontal transect	Quattrini and Ross (2006)
Hyrdrobotics Orpheus/DOE HD2	Artificial	Oil/gas platform	Cylindrical/depth interval	Stanley and Wilson (1997)
Hyrdrobotics Orpheus/DOE HD2	Artificial	Oil/gas platform	Cylindrical/depth interval	Stanley and Wilson (2000)
Phantom HD2/VideoRay Pro II	Artificial	Oil/gas platform	Cylindrical/depth interval	Wilson et al. (2006)
VideoRay ROV	Artificial	Debris field	Horizontal transect	Gallaway et al. (2008)
XL-11 ROS camera	Artificial	Deep-water shipwreck	Horizontal transect	Kilgour and Shirley (2008)
VideoRay Pro III	Artificial	Concrete pyramids	Cylindrical point count	Patterson et al. (2009)
VideoRay Pro III	Artificial	Concrete pyramids	Cylindrical point count	Dance et al. (2011)
Hyball	Artificial	Oil/gas platform	Cylindrical/depth interval	Andaloro et al. (2013)

has the potential to greatly influence distribution and abundance of fish over a large area. Historically, these habitats have been conducive to survey methodologies that have generally involved straight-line horizontal transects and/or randomized drops of the ROV onto benthic habitats. As an index of survey effort, these protocols typically use a measure of transect distance, which can be computed from an ultra-short baseline (USBL) acoustic positioning system or extrapolated from survey time and a constant ROV speed. In these applications, the ROV is typically either "flown" away from a stationary vessel or suspended with a clump weight away from the ship and towed along a transect with limited maneuverability (Bryan et al., 2013; Pacunski et al., 2008). These types of ROV-based approaches generally involve sampling over large expanses of contiguous substrata often several square kilometers in size, and are unfortunately not always applicable to surveys of more isolated large habitats (e.g., pinnacle reefs, high relief artificial structures).

The majority of the benthos in the western Gulf of Mexico is characterized by clay, sand, or silt material (Parker et al., 1983). This general lack of complex bottom habitat relative to other areas has led to a great dependence on artificial reefs by fishermen and divers in this region, as these structures concentrate high densities of fish. The type and amount of artificial structure varies greatly throughout the Gulf of Mexico basin. For example, eastern programs (Florida and Alabama) have large numbers of small reef pyramids (2.5 m height × 3 m base), reef balls, and military tanks (7 m × 3.4 m × 3.2 m). Louisiana and Texas artificial reef programs consist largely of toppled or partially removed (cut-off) oil and gas platforms that are much larger in size (3800–8173 m^2). The state of Texas has one of the largest Rigs-to-Reefs programs in the United States and has reefed 140 oil and gas platforms since 1990. Despite several decades of reefing, there have been few assessments of fish populations using these submerged artificial structures, and previous authors have suggested that reefed platforms may not be as productive as standing structures or natural reef habitats (Stanley and Wilson, 1997, 2000a; Wilson et al., 2003). Because of the recent rapid removal of standing structures in the Gulf of Mexico, and the subsequent conversion of a portion of those to Rigs-to-Reefs programs, critical questions related to the construction and placement of artificial reefs remain to be addressed. For instance, it is unknown which Rigs-to-Reefs option (e.g., toppled versus partial removal) best supports fisheries production and diversity due to a lack of standardized fishery-independent surveys on these structures.

In the northern Gulf of Mexico, ROV methods to estimate fish density at smaller scale artificial reefs have been developed. For example, some researchers have modified stationary point count (SPC) methods of Bohnsack and Bannerot (1986) to estimate fish density within a cylinder comprising the physical footprint of a pyramid (Dance et al., 2011; Patterson et al., 2009). For larger scale artificial reefs composed of oil and gas platforms, previous studies have used SCUBA surveys, manned submersibles, or hydroacoustics to assess fish density or community structure (Andaloro et al., 2013; Dokken et al., 2000; Gallaway et al., 2008; Love and York, 2006; Rooker et al., 1997; Stanley and Wilson, 1997, 2000a; Wilson et al., 2003), and the use of ROVs has been secondary. Typically, those ROV surveys used cylindrical point counts and were confined to pre-determined depth and time intervals (Table 1). Because previous studies in the Gulf of Mexico have been focused on extrapolating density estimates of fish from a proportion of the total habitat (Gallaway et al., 2008; Stanley and Wilson, 1997, 2000a; Wilson et al., 2003), these assessments have not comprehensively evaluated the fish community on these structures.

In this study, we describe a rapid ROV-based assessment protocol for acquiring abundance and diversity indices for reef fishes on artificial reefs created by oil and gas platforms. Given the size, depth, and high relief of these offshore structures (10s of m, tall and wide), we integrated ROV sampling methodologies previously used for both large and small scale habitats, namely depth interval-based and roving (horizontal and vertical) transects. In our assessment, we discuss some of the challenges and logistical constraints associated with implementing ROV surveys in this region and compare and contrast the two techniques that should prove beneficial to researchers assessing the value of artificial reefs in enhancing fish populations.

2. Materials and methods

2.1. Artificial reef site description and location

Our study region comprised 14 artificial reef sites situated along the coastal-bend of south Texas in shelf waters of the Gulf of Mexico (Fig. 1). Multiple structures of varying materials were reefed within each artificial reef site. The predominant bottom type surrounding the reefs was a silt-clay mixture. A total of 20 ROV surveys were completed on various artificial structures in 2012 (Table 2). These